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DEPARTMENT OF NATURAL RESOURCES AND ENERGY
NEW BRUNSWICK
HON. MORRIS GREEN, MINISTER

GEOLOGICAL NOTES SERIES
PM 89-70

LITHOGEOCHEMISTRY
(Co, Ni, Cu, Zn, Pb, As, Mo, Ag, Sb, W, Au, Pt, Pd) OF THE McADAM-ST. CROIX RIVER AREA, NEW BRUNSWICK
(NTS 21 G/11c, d, and 21 G/6e)

by

L.R. Fyffe

(1989)

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LITHOGEOCHEMISTRY

(Co, Ni, Cu, Zn, Pb, As, Mo, Ag, Sb, W, Au, Pt, Pd)

OF THE McADAM-ST. CROIX RIVER AREA, NEW BRUNSWICK

(NTS 21 G/11c, d, and 21 G/6e)

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Minerals and Energy Division
Department of Natural Resources and Energy
P.O. Box 6000, Fredericton
New Brunswick E3B 5H1

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Author: L.R. Fyffe

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LITHOGEOCHEMISTRY
(Co, Ni, Cu, Zn, Pb, As, Mo, Ag, Sb, W, Au, Pt, Pd)
OF THE McADAM-ST. CROIX RIVER AREA, NEW BRUNSWICK
(NTS 21 G/11c, d, and 21 G/6e)

INTRODUCTION

The McAdam-St. Croix River area is located approximately 135 km southwest of Fredericton along the border between Maine and New Brunswick (Plate 89-70). The geology of three 1:20 000 scale maps (21 G/11c, d, and 21 G/6e) was completed during the 1988 field season. The area is largely covered by a coniferous forest that generally takes the form of cedar swamps near major waterways. Outcrops are restricted to the main highways, lumber roads, and the St. Croix and Canoose rivers. Because of the poor exposure, LANDSAT-MSS lineament trend maps were prepared (Geodat 1988a - f). However, the strong glacial overprinting in the area limits their application in regard to bedrock mapping.

STRATIGRAPHY AND STRUCTURE

A fault-bounded belt of Ordovician rocks (Unit Os), located in the northwest corner of 21 G/6e (Plate 89-70), trends from the St. Croix River northeasterly to Halls Brook. This unit comprises interstratified black pelites and light grey psammites, ranging from 1 to 30 cm in thickness. The severely contorted nature of these beds readily distinguishes them from younger rocks in the area.

The shallow dips of bedding in the Ordovician rocks are a consequence of tight recumbent folding and are in marked contrast to the steep attitudes in the adjacent Silurian strata to the northwest and southeast. The recumbent folds are deformed by more open, upright folds that plunge gently to the northeast. The cleavage, which is axial planar to these later folds, parallels the fold trend in Silurian rocks. The pelites and psammites possess a strong preferred orientation of micas indicating regional metamorphism in the greenschist facies. The Ordovician age for these rocks is assigned on the basis of their lithological and structural similarity to the lower Tetagouche Group of central New Brunswick.

The greater part of the McAdam-St. Croix River area is underlain by a thick clastic, dominantly turbiditic sequence deposited within the Silurian Fredericton Trough (McKerrow and Zeigler 1971). The turbidites (Unit Ss) can be divided into two lithological packages: very thick bedded (up to 1 m), medium-grained, quartzofeldspathic sandstone and minor dark grey slate, dominant to the northwest of the Norumbega-Fredericton

fault zone (Plate 89-70); and fine- to medium-bedded, fine-grained calcareous sandstone, light green slate, dark grey pyritiferous slate, flaggy mica-rich sandstone, and thick-bedded, medium-grained, quartzofeldspathic sandstone to the southeast of the fault. Their detrital texture shows little evidence of recrystallization, suggesting subgreenschist regional metamorphism.

No fossils have been recovered from the Fredericton Trough in southwestern New Brunswick. Ruitenberg and Ludman (1978) include the rocks of the McAdam-St. Croix River area in the Digdeguash Formation, but abundant black slate and granule conglomerate characteristic of that formation do not occur in the area. However, the turbidites in the southeastern part of the area, lithologically resemble the Flume Ridge Formation (Ruitenberg 1968), and the late Llandoverian to Wenlockian Waterville Formation in Maine (Osberg 1968). The Flume Ridge Formation overlies the Digdeguash Formation in the type area.

The thick-bedded turbidites in the northwestern part of the area do not resemble either the Digdeguash or Flume Ridge formations. However, they are similar to, and on strike with, the Wenlockian Sangerville (formerly Vassalboro) Formation in Maine (Osberg 1968; 1988), and the graptolite-bearing, Wenlockian to Ludlovian "Burtts Corner greywacke" (Berry and Boucot 1970) exposed on the Trans-Canada Highway west of Fredericton.

Bedding in the Silurian rocks strikes to the northeast with steep dips either to the northwest or southeast. Actual fold closures associated with the vertical axial planar slaty cleavage have not been observed, but the ubiquitous steep bedding attitudes suggest that the folds are tight. Bedding-cleavage intersections indicate that these folds plunge gently to the northeast. A later conjugate set of vertical kink folds can be seen in most exposures. The sinistral kink band has a strike of 90° and the dextral band, 130° indicative of shortening approximately parallel to bedding. Steep northeast-trending and subhorizontal kink folds have been observed locally.

The northern portion of the map area is underlain by the Early Devonian Pokiok granite batholith (Unit Dg). The granite is coarse grained, equigranular, and contains about 10% biotite. A fine-grained, quartz-feldspar porphyry dyke intrudes the granite on Howland Hill. Thermal effects of the granite, which include the growth of andalusite and biotite, can be recognized in the surrounding Silurian country rocks up to one kilometre from the contact. Veins of leucogranite transect the country rocks a few metres from the contact.

A narrow, fault-bounded, discontinuous belt of Carboniferous redbeds (Unit Cs) extends from the mouth of Simsquish Brook on the Maine side of the St. Croix River (21 G/6e) to just east of

the Digdeguash River (21 G/11c). No fossils have been discovered in these rocks, so they could conceivably be as old as mid-Devonian.

Thick beds of maroon conglomerate, interstratified with rare red sandstone beds ranging from 1 to 6 cm in thickness, can be traced from the County Line Road northeastward beyond Brandy Hill on Highway 630. The conglomerate contains clasts of Silurian sandstone, milky quartz, maroon sandstone, and minor black chert and mafic volcanic rocks. It forms beds from 20 cm to a metre and more in thickness, exhibits cut-and-fill structures, contains rounded clasts ranging from 3 to 15 cm in size, and is clast supported. These features are typical of a braided-stream environment. Pebble imbrication indicates a southward transportation direction. Very thick bedded conglomerate southwest of Brandy Hill, contains angular cobbles up to 25 cm in size and a greater proportion of matrix, and may represent debris flows at the head of an alluvial fan (C. St. Peter, personal communication, 1988).

The redbeds on Simsquish Brook, which apparently occur in a separate graben than that occupied by the conglomerate beds at Brandy Hill, are fine-grained, maroon quartzose sandstones interstratified with rare, coarse-grained arkosic beds about 15 cm thick. A highly sheared wedge of conglomerate is exposed on the St. Croix River about 2.5 km upstream from the mouth of Simsquish Brook.

FAULT TECTONICS

The Norumbega-Fredericton fault zone, which extends from eastern Maine to Fredericton (Ludman 1986), passes through the central region of the McAdam-St. Croix map area. This fault zone has a long history of dextral transcurrent motion (Unger et al. 1987). In the present map area, the counterclockwise orientation of slaty cleavage in Silurian rocks relative to the fault zone is consistent with dextral motion. This sense of displacement must have extended at least into the Middle Devonian since granite of that age is dextrally offset by a few hundred metres in Maine (Wones 1980). The transcurrent Norumbega-Fredericton fault zone may have been localized by pre-existing south-directed thrusts recognized in seismic profiles across southeastern Maine (Unger et al. 1987). Several major east-northeast-trending faults in the McAdam-St. Croix River area form part of the Norumbega-Fredericton fault zone. Evidence for the existence of these faults is described below.

Extensive quartz-flooding and brecciation are present near the northwestern boundary of the Ordovician rocks, along the west-flowing section of the St. Croix River. In addition, a sheared wedge of Carboniferous conglomerate occurs along the southeastern side of the Ordovician rocks. Therefore, the boundaries of the Ordovician rocks are interpreted to be faulted, even though the actual fault contacts are not exposed.

Another fault, extending from Simsquish Brook to Brandy Hill, is delineated by down-dropped Carboniferous redbeds within the Silurian sequence. The nature of this fault can be examined on Simsquish Brook where Carboniferous redbeds dip under Silurian sandstone and slate at an angle of 70° to the northwest. Evidently, high-angle reverse movement has taken place along the re-activated margin of the narrow graben into which the redbeds were deposited. Just north of the confluence of Simsquish Brook on the St. Croix River, ramping of Silurian sandstone over slate within a steep shear indicates sinistral movement has occurred along the same fault. This sense of displacement is supported by the regional change of bedding trends from northeasterly to northerly as the fault is approached.

Minor northeast-trending shears display evidence of dextral motion. This is shown by offsets of quartz veins and bedding planes in exposures on the St. Croix River 1 km south of Simsquish Brook (21 G/6e) and on a lumber road northwest of Trout Brook (21 G/11d). The z-shaped assymetry of a drag fold, exposed along a lumber road 2 km southeast of Brandy Hill (21 G/11c), is in agreement with dextral movement on the Norumbega-Fredericton fault zone.

In summary, the Norumbega-Fredericton fault zone represents a major transcurrent boundary along which Carboniferous sedimentary rocks were deposited in separate pull-apart grabens. Regional structural relationships are consistent with significant dextral motion during which a wedge of Ordovician rocks was emplaced along the fault zone. Locally, there is evidence for sinistral offset but its timing relative to the dextral movement is uncertain. However, a northeast-southwest principal stress orientation, indicated by the presence of late conjugate kink folds, may have produced an episode of sinistral motion following a period of dextral movement.

LITHOGEOCHEMISTRY

Quartz veins are present in most exposures of Silurian rocks in the map area. These veins occur in various orientations, but most commonly trend parallel to bedding. Some are folded and must have been emplaced during or prior to the main deformational event in these rocks. Quartz veining is particularly abundant in the many northeast-trending shear zones throughout the area.

Samples of both veined and unveined sedimentary rocks were collected during the 1988 summer field program. These samples were analysed by X-Ray Laboratories of Don Mills, Ontario for magnesium (Mg), phosphorus (P), calcium (Ca), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), lead (Pb), zinc (Zn), arsenic (As), molybdenum (Mo), silver (Ag), antimony (Sb), tungsten (W), palladium (Pd), platinum (Pt), and gold (Au). The analyses are presented in Table 1, analytical methods and detection limits in Table 2, and sample locations on Plate 89-70.

TABLE 1

ROCK GEOCHEMISTRY: McADAM-ST. CROIX AREA

SAMPLE	Mg	P	Ca	Mn	Fe	Co	Ni	Cu	Zn	Pb	As	Mo	Ag	Sb	W	Au	Pt	Pd
1	14000	560	1800	300	28000	13	31	11.0	49.0	<2	1	<1	<0.5	0.2	<1	1	<10	<2
2	14000	680	11000	340	31000	10	35	10.0	47.0	<2	3	<1	<0.5	0.3	<1	<1	<10	<2
3	15000	560	77000	920	29000	10	33	7.5	47.0	8	10	<1	<0.5	0.5	1	<1	<10	<2
4	38000	410	3000	590	68000	33	130	13.0	120.	<2	4	<1	0.5	0.3	<1	<1	<10	6
5	11000	480	43000	590	24000	9	29	7.5	40.0	4	3	<1	<0.5	0.5	1	<1	<10	<2
6	18000	570	22000	480	31000	12	82	14.0	63.0	2	4	<1	<0.5	0.4	1	<1	<10	<2
7	19000	670	47000	690	33000	12	38	11.0	49.0	4	16	<1	<0.5	0.3	2	6	<10	<2
8	20000	500	55000	770	31000	9	31	13.0	50.0	10	18	<1	<0.5	0.4	<1	<1	<10	3
9	12000	610	1600	300	30000	11	33	9.5	59.0	<2	2	<1	<0.5	<0.2	1	<1	<10	<2
10	13000	630	12000	380	28000	10	29	10.0	50.0	4	2	<1	<0.5	0.8	1	2	<10	<2
11	14000	570	17000	370	26000	10	28	10.0	45.0	2	3	<1	<0.5	0.5	1	2	<10	<2
12	12000	490	9300	310	25000	10	28	10.0	45.0	6	2	<1	<0.5	0.4	<1	2	<10	<2
13	9500	620	4300	250	26000	10	34	12.0	44.0	2	7	<1	<0.5	0.9	1	1	<10	<2
14	8500	650	16000	410	25000	9	25	13.0	35.0	4	4	<1	<0.5	0.9	<1	2	10	<2
15	8900	480	24000	590	19000	5	14	39.0	36.0	4	1	<1	<0.5	0.7	1	<1	<10	<2
16	13000	680	12000	320	32000	11	36	15.0	49.0	<2	15	<1	<0.5	2.0	1	<1	<10	<2
17	14000	640	17000	410	33000	11	38	6.0	57.0	2	9	<1	<0.5	0.6	1	<1	<10	<2
18	16000	580	34000	600	30000	13	61	11.0	47.0	<2	28	<1	<0.5	1.7	2	<1	<10	<2
19	17000	720	61000	800	40000	13	37	11.0	50.0	<2	2	<1	<0.5	0.3	1	<1	<10	<2
20	13000	660	28000	530	29000	11	50	9.0	52.0	<2	25	<1	<0.5	4.2	4	<1	<10	<2
21	12000	590	21000	470	30000	10	29	9.0	49.0	8	3	<1	<0.5	0.4	1	<1	<10	<2
22	17000	680	20000	390	35000	14	40	14.0	61.0	<2	4	<1	<0.5	0.2	<1	<1	<10	<2
23	21000	620	29000	490	40000	16	43	13.0	64.0	<2	1	<1	<0.5	0.7	<1	<1	<10	<2
24	8700	560	56000	580	35000	12	33	27.0	45.0	4	7	<1	<0.5	0.7	1	<1	<10	<2

Results in parts per million (ppm) except for Pt, Pd and Au in parts per billion (ppb)

TABLE 2

ANALYTICAL METHODS AND DETECTION LIMITS

	METHOD	DETECTION LIMIT
Au PPB	FADCP	1.
Mg PPM	DCP	100.
P PPM	DCP	10.
Ca PPM	DCP	100.
Mn PPM	DCP	2.
Fe PPM	DCP	2.
Co PPM	DCP	1.
Ni PPM	DCP	1.
Cu PPM	DCP	0.5
Zn PPM	DCP	0.5
As PPM	NA	1.
Mo PPM	DCP	1.
Pd PPB	FADCP	2.
Ag PPM	DCP	0.5
Sb PPM	NA	0.2
W PPM	NA	1.
Pt PPB	FADCP	10.
Pb PPM	DCP	2.

DCP = double couple plasma
FADCP = fire assay/double couple plasma
NA = neutron activation

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_____ 1988b. McAdam area, parts of NTS 21 G/6 and 21 G/11, LANDSAT-MSS, NE lineament trend map. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 88-50.

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_____ 1988d. McAdam, NTS 21 G/11, sheets c, d; LANDSAT-MSS, N/NE/E lineaments. New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Plate 88-52.

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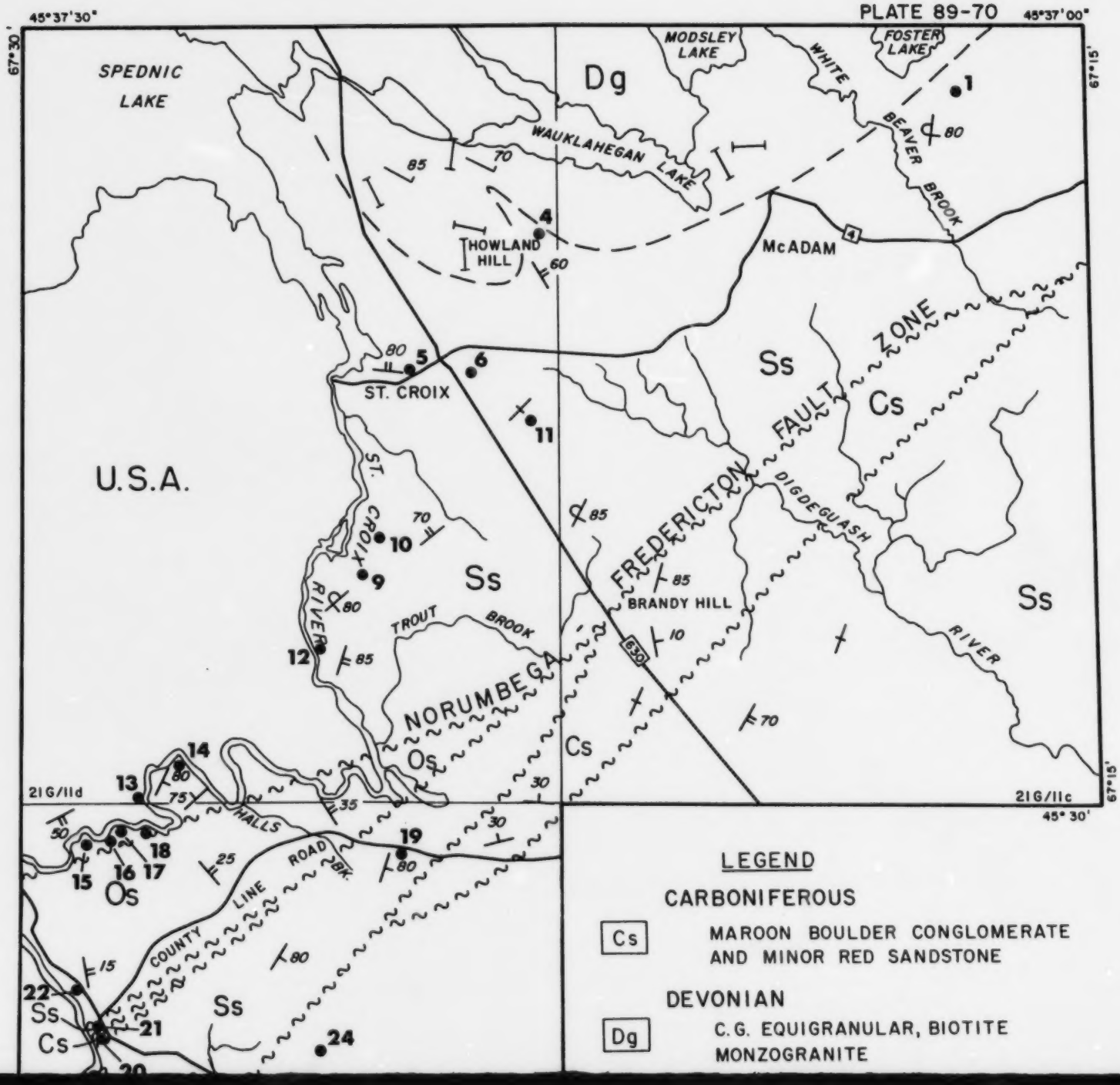
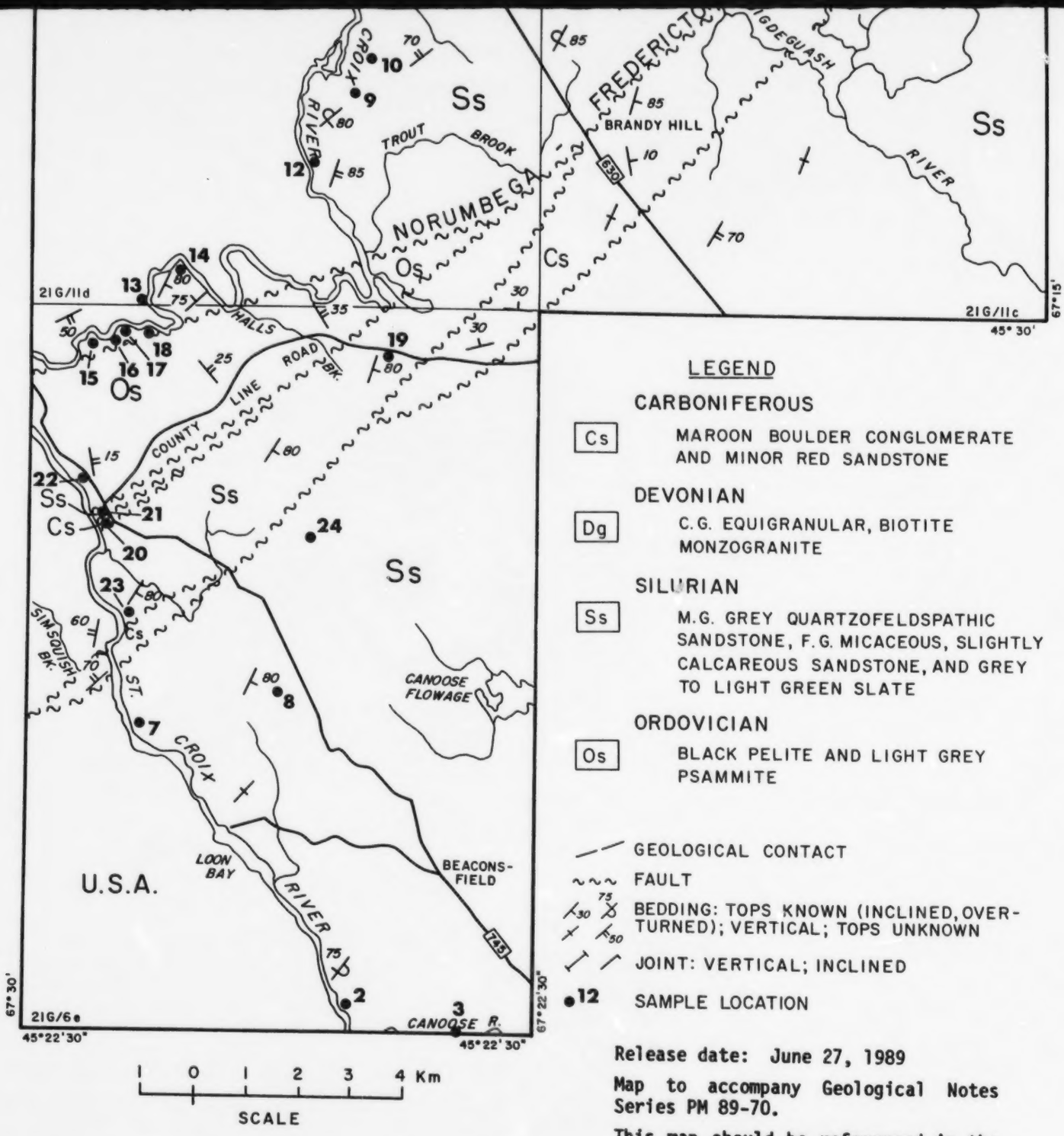
PLATE 89-70


45°37'30"
45°37'00"
67°30'
67°15'
SPEDNIC LAKE
MODSLEY LAKE
FOSTER LAKE
WHITE
BEAVER BROOK
WAUKLAHEGAN LAKE
Dg
HOWLAND HILL
McADAM
ST. CROIX
U.S.A.
ST. CROIX RIVER
TROUT BROOK
NORUMBEGA
FREDERICTON FAULT ZONE
DIGDEGUASH
BRANDY HILL
RIVER
Ss
Cs
Os
HALLS
LINE
ROAD
COUNTY
21G/11d
21G/11c
45° 30'
LEGEND
CARBONIFEROUS
Cs
MAROON BOULDER CONGLOMERATE AND MINOR RED SANDSTONE
DEVONIAN
Dg
C.G. EQUIGRANULAR, BIOTITE MONZOGRANITE



LEGEND

CARBONIFEROUS

Cs — MAROON BOULDER CONGLOMERATE AND MINOR RED SANDSTONE

DEVONIAN

Dg — C.G. EQUIGRANULAR, BIOTITE MONZOGRANITE

SILURIAN

Ss — M.G. GREY QUARTZOFELDSPATHIC SANDSTONE, F.G. MICACEOUS, SLIGHTLY CALCAREOUS SANDSTONE, AND GREY TO LIGHT GREEN SLATE

ORDOVICIAN

Os — BLACK PELITE AND LIGHT GREY PSAMMITE

GEOLOGICAL CONTACT

FAULT

BEDDING: TOPS KNOWN (INCLINED, OVERTURNED); VERTICAL; TOPS UNKNOWN

JOINT: VERTICAL; INCLINED

●12 SAMPLE LOCATION

Geology and Sample Locations in the McAdam – St. Croix River Area, New Brunswick

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Map to accompany Geological Notes Series PM 89-70.

This map should be referenced in the following manner:

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